measured :—C/3—22, 21, 22 × 16, 16·5, 17. Date 16–4–29. C/4—22·5, 23·5, 22, 21·5 × 16·5, 17, 16, 17. Date 16–4–29. The eggs were almost exactly like those in the first nest found. All the nests were in banks, facing more or less east and 2′ 8″ above the path or road. They were all similar in construction to the first nest I took, though they were not perhaps in such a pronounced hole. The situations were rather a fairly pronounced shelf with the back slightly hollow. The usual spot chosen is one where the vegetation is neither very thick nor entirely absent.

TOUNGOO, BURMA, J. M. D. MACKENZIE, I.F.S.
May 11, 1929 .

XXII.—EFFECT OF WIND ON THE FLIGHT OF BIRDS.

(*With 2 diagrams.*)

1. *Effect of wind on Soaring Flight.*

The capacity of a kite for sailing through the air without making the slightest motion of its wings depends altogether on the presence of wind. It is not easy to explain the mechanism within the compass of a short note, but I shall try to do so as briefly as possible. When a kite soars in the true sense, that is when it circles round and round and at each circle increases its height, it does not make actual circles but rather a succession of pear shaped figures. I represent them thus.

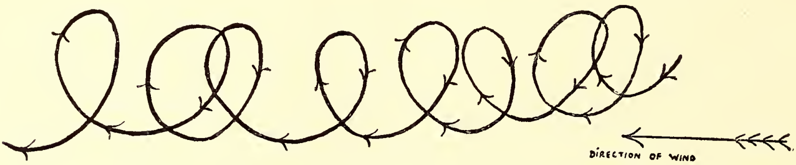

FIG. 1.

Now the capacity to make these figure depends altogether on the presence of wind. If the air is a perfect calm then the bird cannot soar in the true sense. Certainly it may make a fairly long glide, or it may make a short series of circles each of which brings it nearer to the earth, but it cannot circle in such a way that each circle bring it higher into the atmosphere nor continue its circlings for an indefinite time.

The mechanism behind this is very simple but not easy to make clear in a few words. Each circle is a pear-shaped figure and may be divided into segments in relation to the direction of the wind,—

(1) The windward segment, or that part of the segment traced by the bird when it is sailing against the wind.

(2) The leeward segment, or that part of the circle traced by the bird when it is sailing with the wind : represented thus.—

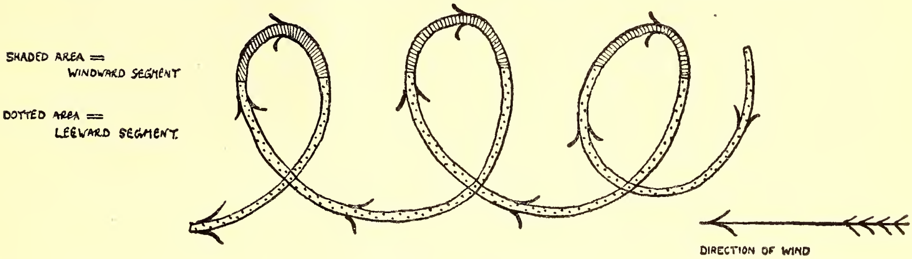

FIG 2.

Now the state of the bird is altogether different in the windward and leeward segments of its circles. When travelling on the windward segment, in other words, when facing the wind, the bird is (*a*) gaining in height, (*b*) losing in velocity, (*c*) travelling a shorter segment of its circle, (*d*) tilting up its under surface so as to come at an incline against the wind.

When, on the other hand, it is in the leeward segment, in other words going with the wind, the bird is (*a*) losing in height, (*b*) gaining in velocity, (*c*) travelling the longer segment of its circle, (*d*) resting with its body horizontal in the air.

Thus we see that there is a complete contrast. The four things which the bird does to the windward are exactly the opposite of what it does to the leeward. Why ? The explanation is very simple, when the bird is travelling to leeward, in other words going with the wind, its object is to develop speed. Its longer sweep, its horizontal attitude, the presence of the wind coming up behind it all help to increase its speed. Then when it circles round to windward, that is when it comes up against the wind, its object now becomes to convert that speed into an increase in height. Hence it can make only a shorter sweep and must incline its body against the wind so that the wind may force it upward.

Thus the kite makes use of the wind in two opposite ways. On the leeward side of its circles the wind gives it speed. On the windward side of its circles the wind gives it an increase in height. The circling of a bird is nothing else than the development of energy of motion on the side of the segment of the circle with the wind, and the conversion of that into energy of position on the segment of the circle against the wind.

But all depends on the presence of wind, without which true soaring is impossible, and by true soaring I mean continuous circling without the slightest motion of the wings and associated with an increase in height.

Effect of wind on Hovering Flight.

Birds that poise themselves stationary at one point in the air, kestrels, kingfishers, terns, for example, make the greatest use of the wind in carrying out these hovering operations. Two points are very obvious, (1) that these birds always face the wind while engaged in the act of hovering, and (2) that they hover with greater ease and facility when the wind is strong than when it is weak. Now why is this? Why is it an advantage to a hovering bird to face a strong wind? Here again I think the explanation is simple. When a bird is in the act of hovering, its wings, each time they are lowered, are thrust in a downward and backward direction. The downward element of the thrust helps to raise the bird, the backward element to push it forward. It remains fixed in the air at one spot. It must in some way counteract the forward push of its wings, which it does by the simple mechanism of persistently facing the wind. No bird can empoly its wings for the purpose of just raising itself vertically; there must always be some forward-pushing element in the strokes. Hence it always faces the wind and hovers more easily when the wind is strong.

Effect of wind on flight at Extreme Altitudes.

I think that at great altitudes birds make use of the wind even more noticeably than they do at sea-level. It is remarkable that they can perform their aërial evolutions at altitudes where the supporting power of the atmosphere is considerably reduced. Soaring flight, for instance, which we have seen is dependent on wind, is performed with perfect ease at 15,000 feet where the supporting power of the atmosphere is reduced to one half. Also I have seen the Lammergeyer soaring at 22,000 feet where the supporting power is still less. Hovering we have seen is dependent on wind, moreover I think that of all the aërial evolutions of birds, it is the one that demands the greatest muscular effort, yet both the kestrel and the tern hover freely where the air has only half its supporting power. So far as ordinary flight is concerned, it has been observed that choughs can fly perfectly well at the immense height of 27,000 feet. Thus it is clear that the lifting power of the air is not of such importance to the flight of birds as has hitherto been thought. I believe that the direction and the force of the wind are factors of far greater importance.

PALL MALL, LONDON. R. W. G. HINGSTON,
April 1, 1929. *Major.*

[In vol. xxx, p. 479 of the Society's *Journal* we published a note by Capt. J. A. Chamier, Royal Air Force on the 'Mechanics of the Soaring Bird' to which Mr. C. H. Donald contributed an interesting comment.

A note on 'Wind and the Flight of Wild Birds' appeared in the *Field* of January 24, 1929. The writer comments on the effect of wind on the flight of rooks. The birds were perfectly helpless against the wind which caught them and whirled them about. A wedge of Pink-footed Geese, flying low, were however unaffected. The direction of the wind, the writer believes, seems to have much more effect on the height at which birds fly than the force of it.